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Provides a method of determining whether weapons and individual equipment (when rigged in common or special purpose containers) jumped by individual parachutists are capable of functioning as intended after landing on the drop zone. The method is limited to items released on a lowering line prior to landing.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-100 3 November 1978
Test Operations Procedure 7-2-512
AD No.

SIMULATED AIRDROP TEST
WEAPONS AND INDIVIDUAL EQUIPMENT

1. SCOPE. This test operation procedure (TOP) describes the test method used to determine whether weapons and individual equipment (when rigged in common or special purpose containers) jumped by individual parachutists are capable of functioning as intended after landing on the drop zone. The items evaluated by this TOP are limited to those released on a lowering line prior to landing, to include missiles and any type organizational or mission equipment jumped by individual parachutists. In the case of explosive materiel, this TOP will NOT be utilized prior to an impact safety evaluation and a determination by test methods specified in TOP 4-2-509[1] and TOP 4-2-601[2] that any hazards involved by the impact of items on the drop zone whether caused by jettisoning or otherwise are acceptable. This TOP will precede test methods specified in TOP 7-3-511[3],

[1]TOP 4-2-509, Airdrop Capability of Explosive Materiel

[2]TOP 4-2-601, Drop Tower Tests for Munitions

[3]TOP 7-3-511, Airdrop Operations - Personnel and Individual Equipment

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that evaluate the compatibility of items with parachute delivery on individual parachutists.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

ITEM	REQUIREMENT
Lateral drift drop tower apparatus - 45 degree incline (See Figure 1)	To provide controlled impacts to the nearest tenth of a foot per second of the test item rigged in its container at a resultant impact velocity of 34.1 feet per second (fps) (10.4 meters per second) with an angle of incidence of 45 degrees from the horizontal plane and with the physical attitude of the test item (angle between the longitudinal axis of the test item and the vertical axis) fixed variously at 15, 30, and 45 degrees. The impact surface is a one-foot thick reinforced concrete slab in the horizontal plane.
Lateral drift drop tower apparatus - 30 degree incline (See Figure 1)	To provide controlled impacts to the nearest tenth of a foot per second of the test item rigged in its container at a resultant impact velocity of 34.1 feet per second (fps) (10.4 meters per second) with an angle of incidence of 30 degrees from the horizontal plane and with the physical attitude of the test item (angle between the longitudinal axis of the test item and the vertical axis) fixed variously at 15, 30, and 45 degrees. The impact surface is a one-foot thick reinforced concrete slab in the horizontal plane.
Environmental chamber	To permit conditioning of test items at 145 degrees Fahrenheit (62.8 degrees Celsius) and -25 degrees Fahrenheit (-31.7 degrees Celsius) or other temperatures specified in requirements documents to the nearest degree Fahrenheit.

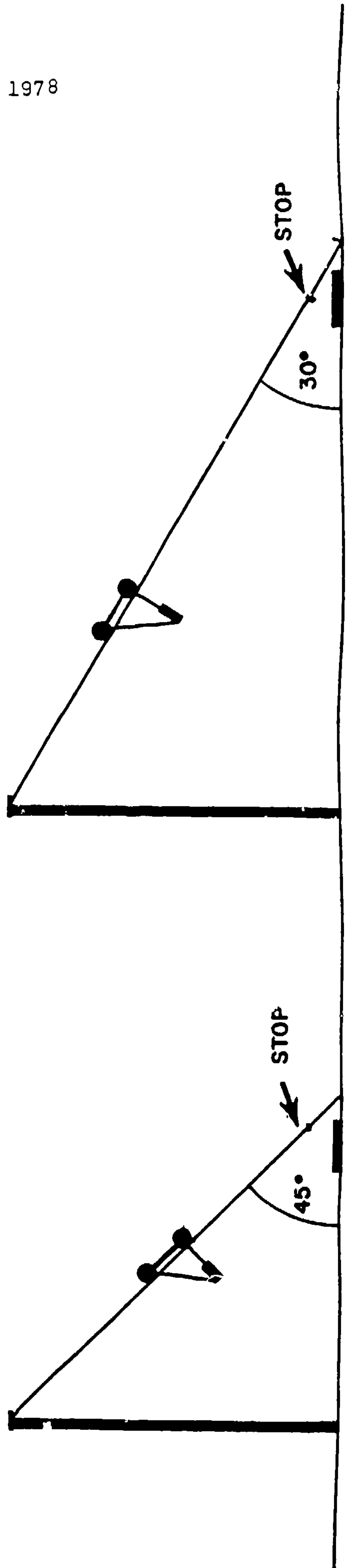

FIGURE 1. SCHEMATIC OF LATERAL DRIFT DROP TOWER APPARATUS

ITEM	REQUIREMENT
Test range	To permit the operation, firing, or other functioning of the test item after it has undergone simulated airdrop. The test range will have those facilities (such as targets) that are appropriate to the item.

2.2 Instrumentation.

ITEM	REQUIREMENT
Electronic timer/recorder	To be attached to the lateral drift drop tower apparatus to measure and record in real time the actual impact velocity of the test item to the nearest tenth of a foot per second.
High speed motion picture camera	To provide visual record of simulated airdrops and post-drop functioning of the test item at approximately 100 frames per second.
X-Ray Equipment	To diagnose and document any internal damage of the test item caused by simulated airdrop.
Meteorological instruments	To measure and record wind direction and speed, ambient temperature, relative humidity and air density to the nearest appropriate unit.
Temperature sensing instrument	To measure and record temperature of environmentally conditioned test items to the nearest degree Fahrenheit.
Accelerometers	To measure and record longitudinal and radial "g" forces "seen" by a mock test item at impact during simulated airdrop to the nearest tenth of a "g." Also used to measure and record any recoil during launching of missiles.

3. PREPARATION FOR TEST.

3.1 Facilities. All facilities will undergo standard pretest operational checks to insure proper functioning. See Appendix A and paragraph 3.3, below.

3.2 Instrumentation. All measuring devices normally calibrated will be checked to insure their calibration is valid. Instruments will be functionally checked as outlined in paragraph 3.3, below, and Appendix A.

3.3 Equipment. Prepare equipment for test as follows:

Step 1. Affix accelerometers at the expected point of impact on a mock test item of the same dimensions and weight as the test item. Also affix accelerometers at the top of the mock test item.

Step 2. Rig the mock test item in its airdrop container in accordance with rigging procedures provided by the US Army Natick Research and Development Command (NARADCOM).

Step 3. Attach the rigged mock test item on the 45 degree incline lateral drift drop tower apparatus with a physical attitude of 15 degrees at approximately 20 feet above ground level.

Step 4. Measure and record wind direction and speed, ambient temperature, relative humidity and air density to the nearest appropriate unit using meteorological instruments.

Step 5. Release the rigged mock test item. The line attached to the bottom of the test item breaks away at impact. The line attached to the top of the test item remains attached at impact with some slack, but of a length which prevents the top of the test item from coming in contact with the impact surface. This eliminates a secondary "slap-down" impact. This snub line must be so "tuned" to limit snatch forces to a maximum of 50 g's. Record the simulated airdrop on high speed, time-marked motion picture film.

Step 6. Record longitudinal and radial "g" forces from the accelerometers.

Step 7. Record the actual resultant impact velocity from the electronic timer/recorder.

Step 8. Repeat Steps 1 through 7 and adjust the height at which the rigged mock test item is attached on the 45 degree incline lateral drift drop tower apparatus if the actual resultant impact velocity deviates more than .5 foot per second from 34.1 feet per second. Continue repetitions until this tolerance is achieved.

Step 9. Repeat steps 1 through 7 with the rigged mock test item at a physical attitude of 30 degrees.

Step 10. Repeat steps 1 through 7 with the rigged mock test item at a physical attitude of 45 degrees.

Step 11. Repeat steps 1 through 8 on the 30-degree incline lateral drift drop tower apparatus.

Step 12. Repeat steps 1 through 7 on the 30-degree incline lateral drift drop tower apparatus with the rigged mock test item at a physical attitude of 30 degrees.

Step 13. Repeat steps 1 through 7 on a 30-degree incline lateral drift drop tower apparatus with the rigged mock test item at a physical attitude of 45 degrees.

Step 14. Compare the actual longitudinal and radial "g" forces obtained during simulated airdrop of the rigged mock test items (in which the actual resultant impact velocities did not deviate more than .5 foot per second from 34.1 feet per second) with the test item design "g" forces provided by the appropriate Materiel Research and Development Command. If actual "g" forces exceed design "g" forces, the test is terminated.

Step 15. X-ray 22 test items to insure no predrop damage exists.

Step 16. Operate the 22 test items on the test range, if feasible, to determine whether they function as intended prior to simulated airdrop. Record this step on motion picture film if appropriate. Record operating parameters of the test items.

Step 17. Rig the 22 test items in their airdrop containers in accordance with rigging procedures provided by NARADCOM.

Step 18. Place one rigged test item in the environmental chamber and condition to a temperature of 145 degrees Fahrenheit (or other temperature specified in the requirements document) for a period of 24 hours prior to simulated airdrop. Record the temperature of the test item with the temperature sensing instrument just prior to simulated airdrop.

Step 19. Place one rigged test item in the environmental chamber and condition to a temperature of -25 degrees Fahrenheit (or other temperature specified in the requirements document) for a period of 24 hours prior to simulated airdrop. Record the temperature of the test item with the temperature sensing instrument just prior to simulated airdrop.

3.4 Data Required.

3.4.1 For each simulated airdrop during the preparation for test, the following data are required. Data collection sheets are at Appendix B.

a. Type of test item.

b. Serial number of the mock test item.

c. Data and time of simulated airdrop.

d. Wind direction and speed in degrees from north to the nearest degree and knots to the nearest tenth of a knot.

e. Ambient temperature in degrees Fahrenheit to the nearest degree.

f. Relative humidity to the nearest percent.

g. Air density in pounds per cubic foot to the nearest tenth of a pound per cubic foot.

h. Actual resultant impact velocity in feet per second to the nearest tenth of a foot per second.

i. High speed, time-marked motion picture film record of the simulated airdrop using approximately 100 frames per second.

j. Physical attitude of the rigged test item in degrees to the nearest degree.

k. The type lateral drift drop tower apparatus used, whether 30-degree or 45-degree incline.

l. Longitudinal and radial "g" forces.

m. Description of any damage detected.

3.4.2 For each test item, the following data are required during preparation for test. Data collection sheets are at Appendix B.

a. Type of test item.

b. Serial number of test item.

c. X-ray film of each test item.

d. Predrop operating parameters of the test item.

4. TEST CONTROLS. The critical aspect of the simulated airdrop test is the attainment of actual impact velocities of 34.1 feet per second within .5 foot per second. This is achieved as specified in steps 8 and 11 of paragraph 3.3, above. The heights determined during these steps will be utilized as the heights at which the rigged test items will be attached to the lateral draft drop tower apparatus. Other controls to assure tests results are reproducible and that the test is both complete and technically accurate are adherence to the check lists (Appendix A) and accurately and completely recording data from validly calibrated instruments on the data collection sheets (Appendix B).

5. PERFORMANCE TESTS.

5.1 SIMULATED AIRDROP.

5.1.1 Method. The 22 rigged test items will undergo simulated airdrop as follows:

Step 1. Attach and release the rigged test item that was conditioned at high temperature (see step 18 of para 3.3, above) on the 30-degree incline lateral drift drop tower apparatus at the height determined in step 11 of paragraph 3.3, above, and at a physical attitude of 15 degrees.

Step 2. Attach and release the rigged test item that was conditioned at low temperature (see step 19, paragraph 3.3) on the 45-degree incline lateral drift drop tower apparatus at the height determined in step 8, paragraph 3.3, and at a physical attitude of 15 degrees.

Step 3. Attach and release four rigged test items on the 30-degree incline lateral drift drop tower apparatus at the height determined in step 11 of paragraph 3.3 and at a physical attitude of 15 degrees.

Step 4. Attach and release four rigged test items on the 30-degree incline lateral drift drop tower apparatus at the height determined in step 11, paragraph 3.3, and at a physical attitude of 30 degrees.

Step 5. Attach and release two rigged test items on the 30-degree incline lateral drift drop tower apparatus at the height determined in step 11, paragraph 3.3, and at a physical attitude of 45 degrees.

Step 6. Attach and release four rigged test items on the 45-degree incline lateral drift drop tower apparatus at the height determined in step 8 of paragraph 3.3, and at a physical attitude of 15 degrees.

Step 7. Attach and release four rigged test items on the 45-degree incline lateral drift drop tower apparatus at the height determined in step 8 of paragraph 3.3, and at a physical attitude of 30 degrees.

Step 8. Attach and release two rigged test items on the 45-degree incline lateral drift drop tower apparatus at a height determined in Step 8 of paragraph 3.3, and at a physical attitude of 45 degrees.

5.1.2 Data Required. For each simulated airdrop the following data are required. Data collection sheets are at Appendix B.

a. Serial number of the test item.

b. Date and time of simulated airdrop.

c. Temperature of the test item in degrees Fahrenheit to the nearest degree.

d. Wind direction and speed in degrees from north to the nearest degree and knots to the nearest tenth of a knot.

e. Ambient temperature in degrees Fahrenheit to the nearest degree.

f. Relative humidity to the nearest percent.

g. Air density in pounds per cubic foot to the nearest tenth of a pound per cubic foot.

h. Actual resultant impact velocity in feet per second to the nearest tenth of a foot per second.

i. High speed, time marked motion picture film record of the simulated airdrop using approximately 100 frames per second.

j. Physical attitude of the rigged test item in degrees to the nearest degree.

k. The type lateral drift drop tower apparatus used - whether 30-degree or 45-degree incline.

5.2 POST-DROP INSPECTION.

5.2.1 Method. The 22 test items will be derigged and visually inspected to identify damage caused by simulated airdrop. Each test item will be x-rayed to diagnose internal damage caused by simulated airdrop.

5.2.2 Data Required. For each test item, the following data are required. Data collection sheets are at Appendix B.

a. Description of damage detected visually.

b. X-ray film of each test item.

c. Description of internal damage detected by x-rays.

d. Serial number of the test item.

5.3 POST-DROP OPERATION.

5.3.1 Method. Operate the 22 test items on the test range to determine whether they function as intended after simulated airdrop. The methods will vary in accordance with the nature of the test item. This test should be the same as described in step 16, paragraph 3.3, if it was conducted.

5.3.2 Data Required. For each test item the following data are required. Data collection sheets are at Appendix B.

a. Operating parameters of each test item in appropriate units (e.g., recoil, flight and hit data in the case of missile launchings).

b. High speed, time marked motion picture film record of operation of each test item using approximately 100 frames per second, if appropriate.

c. Serial number of the test item.

6. DATA REDUCTION AND PRESENTATION. Recorded data will be presented on data collection sheets shown in Appendix B. Failure of test items to function as intended (see paragraph 5.3, above) will be correlated with damage caused by simulated airdrop (see paragraph 5.2, above). If all 22 test items function as intended after simulated airdrop, the determination will be made that the test item (when rigged in its airdrop container) is capable of functioning as intended after landing on the drop zone when jumped by individual parachutists. Degradation of performance or failure of test items to function as intended after simulated airdrop will be analyzed by appropriate statistical techniques (which varies in accordance with the underlying failure distribution of the test item). In such a case, the probability will be given that the test item (when rigged in its air-drop container) is capable of functioning as intended after landing on the drop zone when jumped by individual parachutists.

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APPENDIX A

CHECK LISTS

A. PREPARATION FOR TEST CHECK LIST.

1. An impact safety evaluation has previously been conducted and a determination made that any hazards involved by the impact of items on the drop zone whether caused by jettisoning or otherwise are acceptable (para 1).

2. All test facilities have undergone standard pretest operational checks in accordance with their operations manual (para 3.1).

3. Calibration of measuring devices normally calibrated are valid (para 3.2).

4. Each step (steps 1 through 19, para 3.3) has been accomplished.

B. PERFORMANCE TESTS CHECK LIST.

1. Each step (steps 1 through 8, para 5.1.1) of the simulated airdrop test has been accomplished and the data required (para 5.1.2) has been recorded on the data collection sheets (Appendix B).

2. All test items have been inspected and x-rayed and a description made of any damage caused by simulated airdrop (para 5.2).

3. All test items have been operated on the test range after simulated airdrop and operating parameters of each test item has been recorded on the data collection sheets (Appendix B) (para 5.3).

APPENDIX B

DATA COLLECTION SHEETS

	(Column for each drop)
Drop No.	
Date	
Time	
Location	
Wind direction	
Wind speed	
Ambient temperature	
Relative humidity	
Air density	
Type of test item	
Serial number of test item	
Temperature of test item	
Type of lateral drift drop tower apparatus	
Physical attitude of test item	
Height of attachment of test item	
Actual resultant impact velocity	
Longitudinal and radial peak "g" forces	
Description of any damage	
Post-drop operating parameter X	
Post-drop operating parameter Y	
Post-drop operating parameter Z	
Pre-drop operating parameter X	
Pre-drop operating parameter Y	
Pre-drop operating parameter Z	
Pre-drop x-ray attached	
Post-drop x-ray attached	

APPENDIX C

STATISTICAL ANALYSIS OF RESULTANT IMPACT VELOCITY VECTORS

1. The purpose of this analysis is to establish test conditions for simulated airdrop of weapons and individual equipment that are jumped by individual parachutists and released on a lowering line prior to landing. The objective of the simulated airdrop test is to determine whether weapons and individual equipment are capable of functioning as intended after landing on the drop zone.

2. To determine what resultant impact velocity magnitude should be selected as the test condition for simulated airdrop, the US Army Yuma Proving Ground conducted a Research Test of Impact Velocities and Forces Encountered by Individual Weapons and Equipment During Personnel Airborne Operations during the period 11 July to 8 September 1977[4]. Resultant impact velocity is the actual velocity at which the item hits the ground and is made up of vertical rate of descent, lateral drift, and oscillation components. A total of 58 instrumented drops were conducted; the magnitude and angle of incidence from the horizontal plane of the resultant impact velocity vectors, and the types of drops are displayed in Table 1 on page C-2.

3. Analyses were performed to select a probability distribution that adequately describes the resultant impact velocity vectors encountered by weapons and individual equipment that are jumped by individual parachutists and released on a lowering line prior to landing. The selected distribution would then be used for prediction of resultant impact velocity magnitudes greater than or less than specified values.

a. Four types of drops were made to collect resultant impact velocity data. To determine whether all data could be combined and considered as a sample from one population, an analysis of variance was performed. This analysis compares average impact velocities among the four types of drops. The data were treated in a two-way layout with unequal samples per cell. Tabulations of sample sizes, weighted means of the magnitudes of the resultant impact velocity vectors, and the customary analysis-of-variance table are displayed in Tables 2, 3, and 4, respectively.

[4]Final Letter Report, STEYP-MTA, YPG, to be published, subject: Research Test of Impact Velocities and Forces Encountered by Individual Weapons and Equipment During Personnel Airborne Operations, TECOM Project No. 8-EG-065-000-022.

TABLE 1. RESULTANT IMPACT VELOCITY VECTORS

Magnitude (fps)	Angle (degrees)[a]	Type Drop[b]	Magnitude (fps)	Angle (degrees)	Type Drop
41.95	(30.1)	C	21.48	(62.1)	C*
34.50	(47.7)	C*	21.31	(56.2)	C
32.84	(26.1)	C	21.08	(75.1)	D
31.73	(33.8)	C*	21.03	(68.7)	D
31.70	(45.1)	C	20.72	(62.5)	C
30.97	(40.3)	C*	20.64	(72.0)	C
30.92	(40.8)	C	20.56	(47.3)	D*
30.80	(33.2)	D*	20.56	(46.7)	D
30.62	(34.4)	D*	20.51	(73.4)	D
30.47	(51.6)	D*	20.50	(61.4)	C
27.89	(47.4)	D*	20.27	(83.7)	D
27.65	(55.0)	D	19.68	(69.6)	C*
26.83	(58.7)	D	19.40	(25.0)	C
26.68	(50.4)	D*	19.37	(81.5)	D
26.42	(56.8)	D	19.12	(78.1)	D
25.81	(41.3)	D	19.10	(58.1)	D
25.41	(47.4)	C*	19.05	(63.2)	D
25.00	(59.6)	C*	17.81	(61.0)	D*
24.84	(67.9)	D	17.76	(80.4)	C
24.41	(68.1)	C	17.40	(77.6)	D
23.95	(59.3)	D*	17.35	(57.7)	C
23.86	(44.1)	D*	16.87	(67.4)	C
23.39	(37.5)	D	16.76	(76.8)	D
23.14	(37.3)	D	15.91	(70.4)	C*
22.90	(58.4)	D	15.90	(67.7)	C
22.87	(60.3)	C	15.63	(80.8)	C
21.79	(66.4)	C	15.10	(77.2)	D*
21.71	(83.2)	C	15.05	(61.2)	D
21.57	(71.2)	D	13.05	(56.9)	D

[a] Velocity vector angle of incidence from the horizontal plane.

[b] "C" denotes personnel jump with Container, Weapons and Individual Equipment.
"C*" denotes dummy drop with Container, Weapons and Individual Equipment.
"D*" denotes dummy drop with DRAGON Missile Jump Pack.
"D" denotes personnel jump with DRAGON Missile Jump Pack.

TABLE 2. SAMPLE SIZES

Type Drop	Item Dropped DJP[a]	CWIE[b]	Total
Personnel Jumps	22	18	40
Dummy Drops	10	8	18
Total	32	26	58

a. "DJP" denotes DRAGON Missile Jump Pack.
b. "CWIE" denotes Container, Weapons and Individual Equipment.

TABLE 3. WEIGHTED MEANS OF THE MAGNITUDES OF THE RESULTANT IMPACT VELOCITY VECTORS

Type Drop	Item Dropped DJP[a](fps)	CWIE[b](fps)	Combined(fps)
Personnel Jumps	21.13	23.02	21.98
Dummy Drops	24.77	25.58	25.13
Combined	22.27	23.81	22.96

a. "DJP" denotes DRAGON Missile Jump Pack.
b. "CWIE" denotes Container, Weapons and Individual Equipment.

TABLE 4. ANALYSIS OF VARIANCE

Category	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio
Personnel vs Dummy[a]	118.3743	1	118.3743	3.7447
DJP vs CWIE[b]	22.2650	1	22.2650	.7157
Interaction	3.5268	1	3.5268	.1134
Error	1706.9916	54	31.1096	
Total	1868.6064	57	32.7826	

a. "Personnel vs Dummy" denotes Personnel Jumps versus Dummy Drops.
b. "DJP vs CWIE" denotes DRAGON Missile Jump Pack versus Container, Weapons and Individual Equipment.

The F-ratio for the main effect (Personnel Jumps versus Dummy Drops) falls at the .06 level of significance. The other F-ratios in Table 4 are small and not significant. The difference in average impact velocity between personnel jumps and dummy drops was about 3.2 feet per second, the dummy drops having the higher average. That the resultant impact velocities of dummy drops were higher was expected because the MC1-1 canopy tends to "run" with the wind wher not manually controlled. The dummy drops were conducted to simulate the horizontal drift obtained during personnel jumps in surface winds greater than 12 knots. Only one of the 40 personnel jumps was conducted in winds greater than 12 knots (14.5 knots, resultant impact velocity 21.57 feet per second). This is less than three percent, whereas it is considered that at least 12 percent of personnel jumps are conducted in surface winds greater than 12 knots. Furthermore, the resultant impact velocities of personnel jumps have a larger range of values than (and include) the range of values for resultant impact velocities of dummy drops. It is, therefore, considered that the resultant impact velocities of the 18 dummy drops are representative of those that would be encountered during actual personnel jumps. Results of this analysis indicate the resultant impact velocity magnitudes of the four types of drops are representative of resultant impact velocity magnitudes of a single population that embodies the many variables encountered in actual personnel jumps.

b. To determine whether the population is described by the normal distribution, a Chi-Square goodness of fit test was conducted as displayed in Table 5.

TABLE 5. CHI-SQUARE GOODNESS OF FIT TEST

Velocity Interval (fps)	Expected Frequency	Observed Frequency	Chi-Square
<17.42 - 17.42	9.67	10	.01149
17.42 - 20.50	9.67	10	.01149
20.50 - 22.96	9.67	14	1.94253
22.96 - 25.42	9.67	8	.28736
25.42 - 28.50	9.67	6	1.39080
28.50 - >28.50	9.67	10	.01149
		Chi-Square	3.655

In this test, Chi-Square has three degrees of freedom and the level of significance is .302. Results of this test indicate there is no significant variation between the measured impact velocity magnitudes and data from the hypothesized population of resultant impact velocities described by the normal distribution with a population mean of 22.96 feet per second and a population standard deviation of 5.73 feet per second.

4. Because the data are accepted as normal, the proportion of resultant impact velocities less than a specified magnitude can be predicted. The magnitude selected as the test condition for simulated airdrop is 34.1 feet per second. This selection is based on the statistical estimate that with 90 percent confidence at least 95 percent of resultant impact velocity magnitudes will be less than 34.1 feet per second. In order to assure test results are reproducible, the impact surface is specified as a one-foot thick reinforced concrete slab. Since the probability of an item landing on concrete during actual personnel parachute jumps is considered low, the selection of a resultant impact velocity greater than 34.1 feet per second is rejected as a test condition.

5. To determine which velocity vector angles of incidence from the horizontal plane should be selected as test conditions, a plot of angles vs. magnitudes of the resultant impact velocity vectors is displayed in Figure 1 on page C-6. By inspection, for magnitudes greater than 30 feet per second, both 30 degrees and 45 degrees are selected as test conditions for the velocity vector angles of incidence.

6. To account for the physical attitude of the item at landing, physical attitudes of 15, 30 and 45 degrees are selected as test conditions.

7. A sample size of 22 simulated airdrops is selected as a test condition in order to permit demonstration of high probability of survivability (90 percent) of the item at high confidence (90 percent).

8. To determine whether secondary "slap-down" impact forces are significant, a comparison of secondary impact forces and initial impact forces was performed. The secondary and initial impact forces of the 18 dummy drops are displayed in Table 6 on page C-7. Only two of the drops had secondary impact forces which exceeded 50 g's, whereas ten of the drops had initial impact forces which exceeded 100 g's. As a test condition, therefore, the secondary impact forces are controlled. A force of 50 g's was selected as the maximum secondary impact force as it is representative of these type forces encountered during actual personnel parachute jumps. To achieve this test condition, a snub line is attached to the top of the test item (simulates action of lowering line) and is of such a length that it prevents the top of the test item from coming in contact with the impact surface. This eliminates excessive secondary "slap-down" impact. Further, the snub line must be "tuned" with sufficient elasticity to prevent excessive deceleration forces (snatch forces) acting on the top of the test item. It is this snatch force which is limited to 50 g's as a test condition.

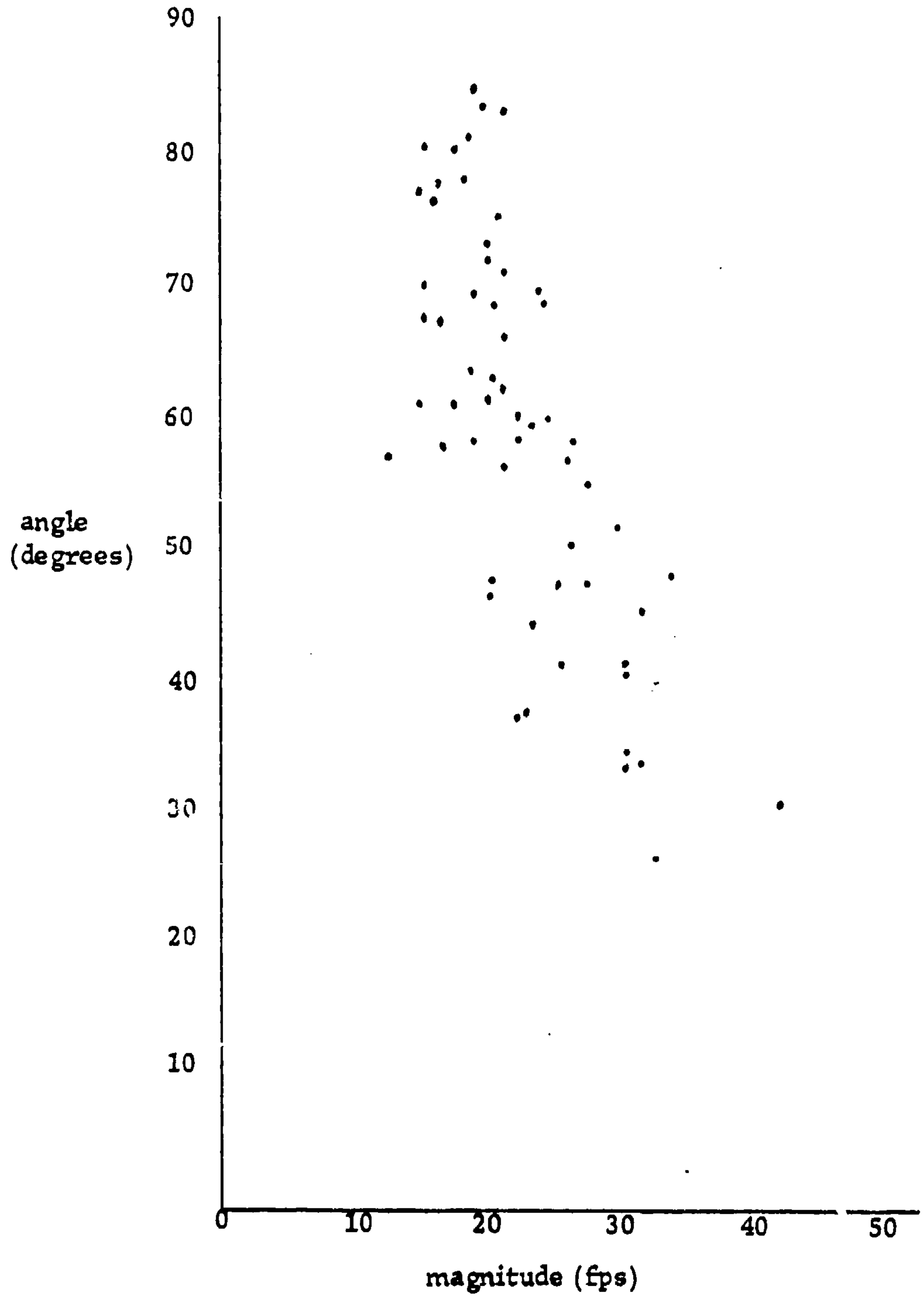

FIGURE 1. RESULTANT IMPACT VELOCITY VECTORS

TABLE 6. IMPACT FORCES

Resultant Impact Velocity Vectors		Initial Impact Forces		Secondary Impact Forces (slap-down)			
magnitude (fps)	angle[a] (degrees)	longitudinal axis (g's)	resultant radial axis (g's)	longitudinal axis (g's)	resultant radial axis (g's)	Item Dropped[b]	Notes
34.50	(47.7)	71.7	102.3	17.6	36.0	CWIE	
31.73	(33.8)	62.8	114.6	70.3	87.7	CWIE	
30.97	(40.3)	70.9	58.1	10.3	18.8	CWIE	1
30.80	(33.2)	lost	lost	lost	lost	DJP	
30.62	(34.4)	119.7	115.1	1.5	6.7	DJP	
30.47	(51.6)	156.6	179.4	55.1	55.3	DJP	
27.89	(47.4)	155.3	117.1	16.4	34.9	DJP	
26.68	(50.4)	38.5	40.1	22.0	10.0	DJP	2
25.41	(47.4)	124.9	105.1	9.4	12.2	CWIE	
25.00	(59.6)	105.2	108.1	22.7	17.0	CWIE	
23.95	(59.3)	88.9	36.3	14.0	6.1	DJP	
23.86	(44.1)	11.4	32.3	8.6	15.1	DJP	3
21.48	(62.1)	108.8	86.9	13.0	8.7	CWIE	
20.56	(47.3)	15.2	17.6	7.3	25.4	DJP	1
19.68	(69.6)	100.9	92.8	5.4	17.9	CWIE	
17.81	(61.0)	69.0	46.3	8.0	35.8	DJP	
15.91	(70.4)	48.9	60.7	10.4	7.2	CWIE	
15.10	(77.2)	60.3	17.7	7.6	16.3	DJP	

a Velocity vector angle of incidence from the horizontal plane.
b "CWIE" denotes Container, Weapons, and Individual Equipment; "DJP" denotes Dragon Missile Jump Pack.

NOTES:
1. Impact surface for these drops was plowed sand; impact surface for all other drops was hard ground.
2. This drop utilized one-layer honeycomb.
3. This drop utilized two-layer honeycomb.

9. A concluding note on the philosophy of conducting simulated airdrop tests instead of actual airdrop tests to determine whether weapons and individual equipment are capable of functioning as intended after landing on the drop zone: The purpose of the tests is to provide high assurance that the items will function as intended in an airborne environment. Referring to Table 1 on page C-2, if actual airdrop tests (or parachute drops from a 250-foot free tower) were conducted, the magnitude of resultant impact velocity vectors obtained would vary over a wide range as would the velocity vector angles of incidence from the horizontal plane. Since, in such a test, no control exists over the resultant impact velocity vectors, in any given test the resultant impact velocities may be unreasonably low or excessively high. Further, results from such tests are not reproducible. Compounding the matter, in such tests, no control exists over the degree of hardness of the impact surface or the physical attitude of the item when it impacts with the drop zone. These objections to actual airdrop tests are overcome by the controls provided in simulated airdrop tests. Only in the event a large number (several hundred) tactical items were available would the results of actual airdrop tests be valid. Even so, simulated airdrop tests would provide valid results with an economy of resources. Referring to Table 6 on page C-7, the question might be asked whether the impact forces should be controlled instead of resultant impact velocities. The answer lies in the fact that impact forces are a function of resultant impact velocity vectors, physical attitudes of the item, the degree of hardness of the impact surface, the effectiveness of impact protection provided by the item's container, and the ruggedness of the item itself. If, as in simulated airdrop tests, the resultant impact velocity vectors, physical attitudes of the item, and the degree of hardness of the impact surface are controlled, then the effectiveness of impact protection provided by the item's container and the ruggedness of the item itself can be determined. Since the item and its container undergo engineering design during development, the effectiveness of impact protection provided by the item's container and the ruggedness of the item itself are the critical variables that determine impact forces and, hence, the degree of survivability of the item in an airborne environment. For this reason, resultant impact velocity vectors are controlled during simulated airdrop tests instead of impact forces.

APPENDIX D

REFERENCES

1. Test Operations Procedure 4-2-509, HQ, TECOM, 26 May 69, with Change 1, 25 Feb 71, subject: Airdrop Capability of Explosive Materiel, AD No. AD-718569.

2. Test Operations Procedure 4-2-601, HQ, TECOM, 10 Apr 70, subject: Drop Tower Tests for Munitions, AD No. AD-870487.

3. Test Operations Procedure 7-3-511, HQ, TECOM, 13 Nov 69, subject: Airdrop Operations-Personnel and Individual Equipment, AD No. AD-867034.

4. Final Letter Report, STEYP-MTA, YPG, to be published, subject: Research Test of Impact Velocities and Forces Encountered by Individual Weapons and Equipment During Personnel Airborne Operations, TECOM Project No. 8-EG-065-000-022.